A FRACTAL JUSTIFICATION OF THE NORMALIZATION STEP FOR ONLINE HANDWRITING RECOGNITION

Vincent, N.; Dorizzi, B.

A FRACTAL JUSTIFICATION OF THE NORMALIZATION STEP FOR ONLINE HANDWRITING RECOGNITION

N. VINCENT

LI/E3i - Université de Tours - 64, av. J. Portalis - 37200 Tours - France
E-mail : vincent@univ-tours.fr

B. DORIZZI

INT - Dept. EPH - 9, rue Charles Fourier - 91011 Evry - France
E-mail : Bernadette.Dorizzi@int-evry.fr

In this paper is presented an example of the use of fractal approaches in the field of online handwriting processing.
The adaptation of the box counting method to the computation of online handwriting fractal dimension is presented. The influence of different parameters is studied. This allows understanding why the value of the proposed parameter is invariant towards the tablet or the speed or the writing size.
The study of the transforms that have been chosen in REMUS software allows seeing that they match quite well the quantitative results obtained with fractal methods. Then, a posteriori, in a theoretical way, this confirms the value of the methods involved.

1 Introduction

Online handwriting recognition is achieved from a time-based representation involving some characteristics of the points issued from a digitizing tablet. According to the tablet, data may comprise for instance the localization of the physical points or the pressure of the pen on the tablet when writing. Most of the methods that are described in the literature use a preprocessing step included in the online handwriting recognizer itself. From this preliminary operation some normalization of the data is expected. One of the goals is to take out some noise that each writer introduces while writing. After normalization, the homogeneity of the patterns involved is expected to be more important.

In this paper we intend to study and to justify some part of the preprocessing most often chosen in order to attain a compromise between recognition rate and processing time. A fractal approach [6,1], already developed in the field of offline recognition [7]will be used to address the problem..

In the first section, fractal dimension will be explained. It will provide a way to quantify the information present in the data. Then the influence of a change of some parameters on the amount of information will be studied. In the last part the normalization choices in the online recognizer REMUS [3], will be justified.

In: L.R.B. Schomaker and L.G. Vuurpijl (Eds.), Proceedings of the Seventh International Workshop on Frontiers in Handwriting Recognition, September 11-13 2000, Amsterdam, ISBN 90-76942-01-3, Nijmegen: International Unipen Foundation, pp 535-540

2 A fundamental tool: the fractal dimension

A quantitative parameter will be introduced. It provides a way to quantify how important is the amount of information contained in data. But, first of all, let us remind the nature of the set of points issued from the tablet. These points can be considered as a sampling of the input word. They are not randomly spread on the plane. In case the points are too sparse, reading would be more difficult. On the contrary, the point set contains some redundancy and this will introduce some noise. The consequence would be a greater difficulty during automatic recognition process.

To measure the complexity of the data inner structure, a fractal approach has been used [4]. It is a global approach.

2.1 Fractal dimension and Box counting method

More precisely we are to compute fractal dimension of the set of points. The box counting method [5] has been chosen because it is quite easy to apply.

Areas of sets deduced from the initial set after dilation are calculated. The area is computed from a grid, meshes of which are called r size square boxes, of unit length. Then, the number of non empty boxes is computed. The r value can vary from 1 pixel to the image size. Fractal dimension is deduced from formula (1).

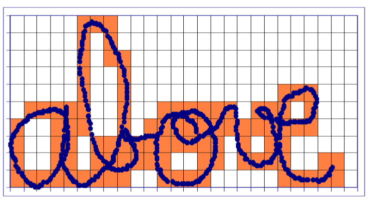
$$d = -\lim_{r \to 0} \frac{\ln(N(r))}{\ln(r)} \qquad (1)$$

The fractal behavior of the studied set is highlighted by the existence of a limit occurring in (1). In practice, the limit computation is possible only if a relation accounts between ln(N(r)) and ln(r) and precisely if it is a linear relation. Then, the computation of the slope of the graph (ln(N(r)) , ln(r)) gives the clue to the problem.

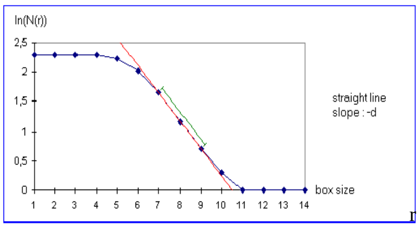
In the box counting method, the considered values of r are powers of 2.

2.2 Adaptation of the method to online writing

The points captured by the tablet are considered without any preprocessing. In figure 1 is shown an example of an online hand written word, on which a 16 pixel wide grid is drawn. The boxes that contain any data point are indicated with a gray level.



(a)



(b)

Figure 1: (a) example of filled boxes associated with an online word
(b) evolution graph for a word – N(r) indicates the number of filled boxes

The evolution graph indicates the evolution of the number of boxes containing a point, and uses log-log representation. An example is presented in figure 1(b). On the x-axis, graduation appears regular indicating only size exponent.

After some precise box size is reached, a single box contains the whole word.

On the left, the horizontal zone indicates that, till 2^5 , the box size gives no significant decrease in the number of filled boxes. The points given by the tablet are rather far one from the other. From this graph zone, it may be thought, the observation scales are not well suited to a global vision. Box size is rather too small.

In order to compute a significant dimension, the central zone of the graph is considered, the most important slope is computed, it is the slope of a straight line computed using three consecutive points and the mean square method.

3 Influence of different factors

In this part, the study will particularly focus on the influence of two factors on the fractal dimension, acquisition rate and the size of the written words. Tests have been achieved on about thirty words from the learning base of REMUS recognizer.

3.1 Speed influence

During the experiments, we have made the writing speed of the writer vary. In fact, we want to simulate the speed level of the tablet. First, we have asked each writer to write a word using a normal speed, then we asked him to pass again on the drawing with a more or less important speed. We limited the experiment to the use of three speeds (low, normal, speedy). In each experiment, a word is written three times by one writer, and for each word the fractal dimensions and the evolution graphs are computed (see figure 2)

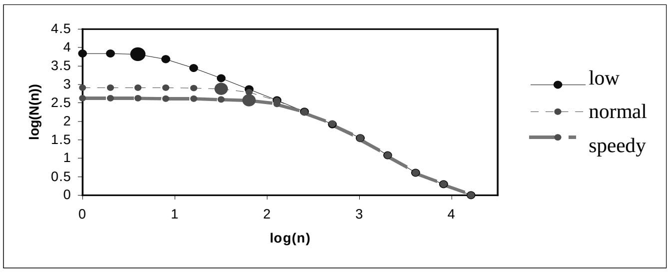


Figure 2: evolution graphs associated with word written with normal, low and high speed

The speedy writing is characterized, in the left part, by a long first horizontal zone. At these observation scales, the points are spread, each one in a box. In case of a slow writing, the captured points are very close one from the other. On the contrary, it can be noticed that in the central zone, where the number of intersected boxes is varying, the slopes are identical what ever writing speed may be.

Then it can be said that the fractal dimension is invariant towards the speed.

Writing speed and tablet resolution do not always match each other well. The rupture point that occurs in the evolution graph, between the left horizontal zone and the actual evolution zone gives an index of their good matching. On each graph of Figure 2, these points have been figured by a larger dot. They indicate the beginning of the interesting zone, the right observation scale.

3.2 Influence of writing size

The goal is to study the influence size variations may have on fractal dimension.

In order to model a change in the size of the writing, an homothety is used. Of course this model is not perfect because, on the one hand, after an homothetic transform, the length of the graphical thread is increased, and on the other hand, the number of data points has not been modified. Nevertheless, the results in the previous part, have shown fractal dimension was invariant towards speed; in the evolution graph, only the length of the left horizontal zone is modified.

Fractal dimension gives some information about the writing style; its value is invariant towards the tablet, the speed and the writing size. Nevertheless, these results do not hold if speed or size are decreased in a too important amplitude. Then, fractal dimension decreases, figuring the loss of information. This phenomenon will be illustrated in next section where normalization preprocessing phase is considered.

4 Fractal dimension and normalization process

In any word recognizer, a normalization step is necessary prior to recognition itself. In this part is considered the influence of this step on the fractal dimension value. The study is limited to preprocessing encountered in REMUS software [2].

Three main processes are achieved : normalization of the text body size, spatial sampling and transformation to obtain an upright writing modifying the shape. Here, this last process will not be considered.

Somehow, recognition consists of comparing two normalized entities. In case of word recognition, the normalization is achieved first on the word body. The normalized height is fixed to 100 pixels, in REMUS software. In order to leave unmodified the global aspect of the writing, the ratio between the initial size and the normalized one is computed and scale transformation is applied on the whole data.

In the second normalization step, on each vertical segment line in the text body, only five uniformly distributed points are to be considered. So, using a linear interpolation method of the data points, a 20-pixel sampling is achieved; a uniform resolution is thus obtained. This transform is motivated by the need to become independent from the variations in the writer speed.

Besides, one of the goals of the system is to achieve a good recognition speed. Then a compromise between the amount of information and the data volume must be achieved. The processing time depends upon the number of data points; reducing their number brings some advantage. Experimentation has shown that, on average, normalization decreases the number of sample points in the ratio of 4 to 1.

Normalization does not modify much the information, but it is compulsory to have a focalization on the data at the right scale. Now we will precise this condition.

The benefit of the normalization has been validated in an empirical way. The recognition rates have been compared according to the precision of the sampling. It came out that the best results were obtained with a 20-pixel sampling. How to prove the truth of what has only been experimented? In Figure 3 the different data can be visually compared according to the distance between two consecutive sample points.

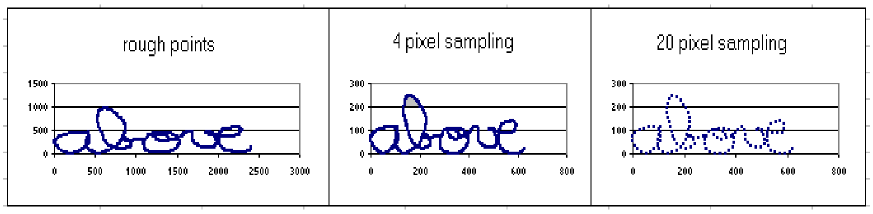


Figure 3: comparison between rough data and data normalized at different resolutions

Fractal dimension can be computed for different values of the sampling resolution. Then, in Figure 4, it can be seen that after normalization of the text body height, the maximum fractal dimension occurs with about 20-pixel sampling. When the distance between two consecutive points is increased, fractal dimension decreases. All the details in the writing have been lost. A resolution has been reached, beyond which value, the number of data points cannot be diminished without some fatal failure in the amount of information. Nevertheless, a constant fractal dimension is observed when the resolution is larger, but then, the number of points in the data gets larger and the points have to be processed during the recognition step itself. There, diminishing the number of points had no effect on fractal dimension. Here, it is shown there exists a maximum unit length so that all the details of the writing are figured. For a 20-pixel resolution, a compromise is reached, involving the number of data points and the information loss.

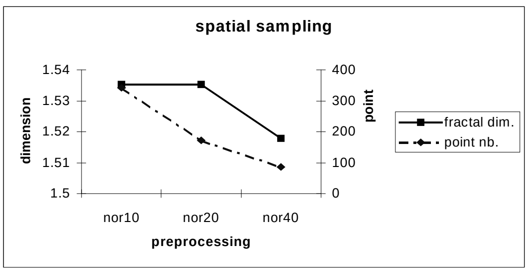


Figure 4: sampling resolution influence

Then, in an objective way, it is shown the normalization defined in REMUS process realizes a good compromise.

5 Conclusion

Difficulty always arises when choosing a preprocessing of data because the improvement of one element often leads to the deterioration of another. To be sure the compromise is efficient, an objective tool would be needed (and not only a visual evaluation), it would allow a quantitative measurement of the modifications within the amount of information. The modification occurs at each step of the process. Here it has been shown that the fractal dimension is an objective and quantitative tool that can be used in the case of online writing.

Further more we have proven the choices achieved in the normalization process of REMUS recognizer were coherent. Indeed, during the transformations, information losses are limited.

References

1. Boulétreau V., Vincent N., Sabourin R., Emptoz H., Synthetic parameters for Handwriting Classification, *4th International Conference on Document Analysis and Recognition*, Ulm (Allemagne), (August 1997), pp. 102-106.
2. Garcia-Salicetti S., Dorizzi B., Gallinari P., Mellouk A., Fanchon D., An HMM extension of a neural predictive system for on line cursive script recognition, *3rd International Conference on Document Analysis and Recognition* (ICDAR'95), Montreal, August 14-16 1995.
3. Garcia-Salicetti S., Dorizzi B., Gallinari P., Wimmer Z., Adaptative Discrimination in an HMM-Based Neural Predictive System for On-line Word Recognition, *12th International Conference on Pattern Recognition*, Vienne, August 1996.
4. Mandelbrodt B., *Fractals : Form, chance, and dimension*. Freeman, San Francisco, 1977.
5. Peitgen H.-O., Jürgens H., Saupe D., *Chaos and Fractals*, New Frontiers of Science, Springer-Verlag, 984 pages, 1992.
6. Vincent N., Boulétreau V., Emptoz H., A fractal analysis of handwritten texts, in *progress in handwriting recognition*, World Scientific, (1995), pp. 581-586.
7. Xi D., Lee S.W., Tang Y., A novel method for discriminating between Oriental and European Languages by fractal features, *13th Int. Conference on Document Analysis and Recognition, Bangalore* (September 1999), pp. 345-348.
8. Wimmer Z., Garcia-Salicetti S., Dorizzi B., Gallinari P., Handwriting word recognition by a neuro-markovian approach : cooperation on-line off-line, *Professional days on Signal processing and Multimedia Technology*, Budapest, Hongrie, (October 1997).